DEVELOPMENT OF THREE CHANNEL LINEAR BIPOLAR HIGH VOLTAGE AMPLIFIER (±2 KV) FOR ELECTROSTATIC STEERER

Rajesh Kumar, Mukesh Kumar, S.K.Suman, C.P.Safvan, A.Mandal
Inter University Accelerator Centre, New Delhi-110067, India

Abstract

Electrostatic steerers and scanners are planned for low energy ion beam facilities at IUAC to steer and scan the ion beam on target. The power supplies for electrostatic steerers are high voltage bipolar DC amplifiers and for scanners are bipolar AC amplifiers. To fulfil the requirements a common unit has been designed and assembled for AC and DC applications. It can be used with electrostatic devices in scanning, steering and sweeping of low energy ion beams at high frequencies to attain uniform implantation. The unit consist of three independent limited bandwidth high voltage, linear bipolar amplifiers (for X-axis, Y-axis and Y1-dog leg plates). The unit has been provided with both local and remote control.

BRIEF DESCRIPTION OF PRODUCT

The instrument is designed in a 19" card frame assembly. All the sub assemblies are card fame type modules interconnected and powered through backplane PCB. The block diagram of the unit is shown in figure-1. The three amplifier modules (X, Y and Y1) provide voltage output upto ± 2 kV in response to ±5 V.

The controller module generates simultaneously three independent bipolar control signals for all the three amplifiers. For X and Y amplifiers, it generates fixed frequency programmable amplitude triangular waves when used with electrostatic beam scanner. DC offset can be added to triangular waves to position the scan on the target. When the amplifier is used with electrostatic steerer, the triangular wave amplitude is kept zero and only bipolar DC-offset control signals are fed so as to have only steering effect. For Y1 amplifier only bipolar DC control signal is generated, because this amplifier is used only with dog-leg plates to steer the beam in both the operating modes (steering and scanning). Test and metering panel measures all the outputs on a common digital panel meter (DPM). In "test mode" this module also provides a common control "test" signal simultaneously to all the amplifiers for calibration and troubleshooting. The local control panel provides DC control signals to controller module. The high voltage power supply module provides ±1100V to all three amplifiers to bias the high voltage push-pull output stage. Low voltage power supply module provides fixed (±15V/1A, ±5V/1A, +10V/0.1A) regulated output voltages to various circuit.

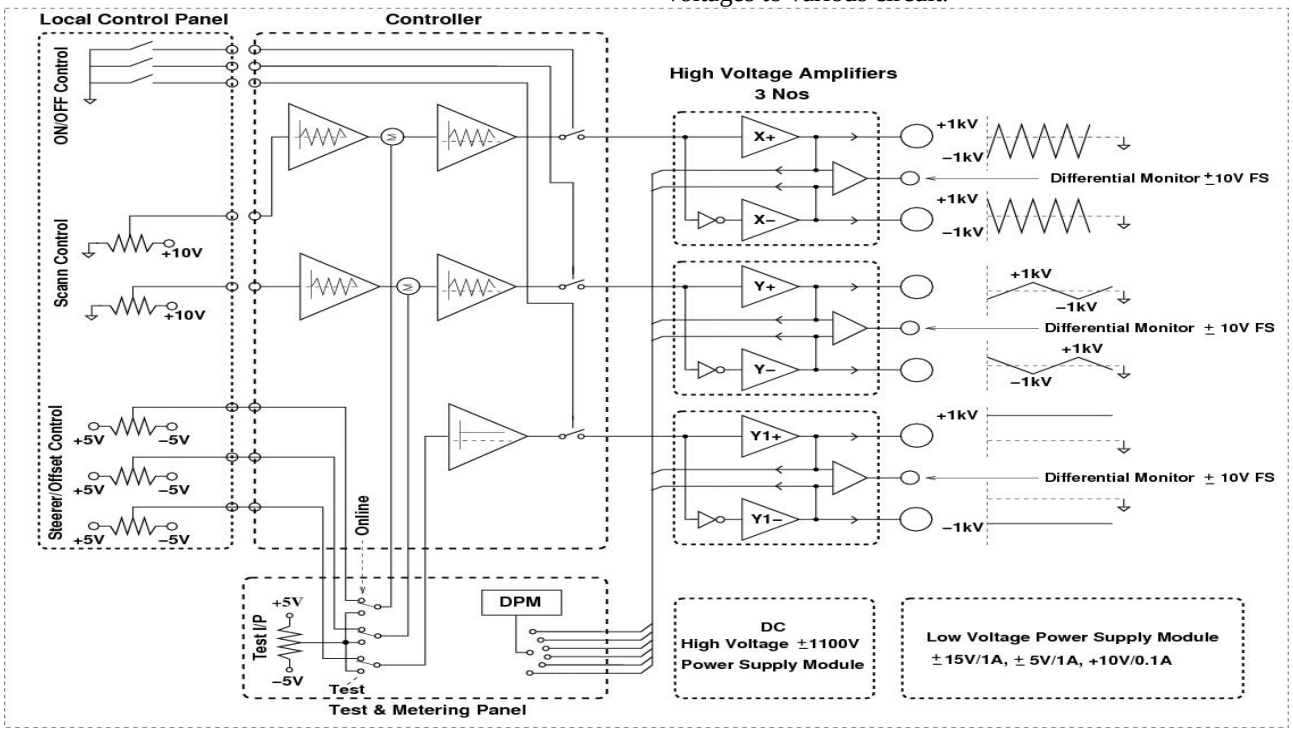

Figure 1: Block Diagram of three channel linear bipolar amplifier

High Voltage Amplifiers

All the three high voltage amplifiers are identical in design and operation. Simplified schematic is shown in figure-2. To generate ±2 kV output, each amplifier module has two identical ±1 kV amplifiers fed simultaneously with out-of-phase signals so that a differential ±2 kV output swing can be achieved. The ±1kV amplifiers are linear bipolar amplifiers based on series negative feedback technique. In output stage high voltage N-channel IGBTs are biased as class B and connected in push-pull configuration. Opto-couplers are used for galvanic isolation between high voltage output stage and input stage.

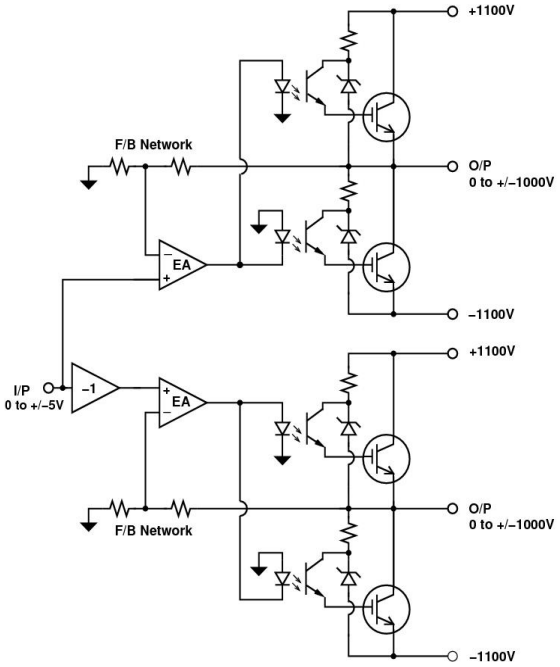

Figure 2: Simplified schematic of ±2 kV amplifier

The input uses a differential error amplifier which servos the drive to opto-coupler such that the feedback nulls the input voltage. Feedback from an output voltage sensing divider is applied to the negative input of the error amp in order to "close the loop". High loop gain feedback overcomes low coupled gain of the opto-coupler at low drive levels and ensures linear operation. The gain and phase response of the error amp is designed to drive capacitive loads (1 nF). The continuous output current limit is 5 mA and the output power limit is 10W. The output is equipped with a current limiting circuit that withstands accidental short-circuits. Each channel has an independent, buffered, voltage monitor output for applications that require a low-level representation of the output signal.

Controller

The simplified schematic of the controller is shown in figure-3. This module generates two independent fixed frequency triangular waves of programmable amplitude of 0 to ±5 V (with a provision for an offset) for the X and Y amplifiers. The frequency of the triangular wave is set to 50 Hz for X-scanning and 0.3 Hz for Y-scanning. The triangular wave generator consists of a fixed frequency bipolar square wave generator and an integrator using operational amplifier. The unipolar scan amplitude control signal is converted to a bipolar square wave using a SPDT analog switch and an inverter. The frequency of the bipolar square wave is controlled by a fixed frequency oscillator. The amplitude of the triangular wave depends on R, C and the input voltage to integrator (Vo= -i/RC*Vin*t). R and C are selected such that at a fixed frequency and 10V input, integrator ramps from +5V to -5V. Amplitude of the triangular wave is controlled by varying the amplitude of the square wave.

Whereas Y1 amplifier is fed only with DC offset signal because it only used for dog-leg steering effect and not for scanning.

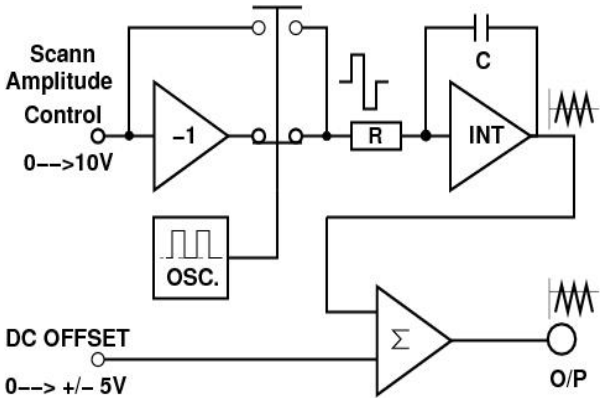

Figure 3: Simplified schematic of triangular wave generator

CONCLUSION

A three channel linear bipolar high voltage amplifiers has been designed, fabricated and tested for specifications. The modular, high density and bipolar amplifier nature of the supply enables a reduction in the number and types of power supplies required as well as the cabling and control complications.